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Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

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Anmelder/Applicant(s)/Demandeur(s):

Koninklijke Philips Electronics N.V.
Groenewoudseweg 1
5621 BA Eindhoven
PAYS-BAS

Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
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If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Method and system for cooling at least one electronic device

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Method and system for cooling at least one electronic device

BACKGROUND OF THE INVENTION

The invention relates to a method for cooling at least one electronic device.

The invention further relates to a system for cooling at least one electronic device.

A method and a system for cooling an electronic device are known from the European patent application EP-A 1 020 911. In the known method and system, a case is mounted onto a heat sink of an electronic device. A vibrating plate is located in the case for moving air through the case, such that the air cools the heat sink of the electronic device. The vibrating plate is driven by an electromagnet.

A disadvantage of the known method is, that it requires a relatively large amount of energy. Furthermore, the heat, which is produced by the electronic device, is wasted. Besides, in the known method and system, the vibrating plate is set in motion using an electromagnet. The resulting electromagnetic radiation may disturb the functioning of the electronic device. Moreover, the amount of cooling as provided by the known method is relatively low.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an alternative method, particularly a better method, for cooling at least one electronic device. The invention aims at providing an efficient method for cooling at least one electronic device.

According to the present invention, this object is achieved by the features of claim 1.

According to the invention, a moving pumping element pumps a fluid to and/or from said electronic device, wherein the movement of said pumping element is induced by heat. The fluid can remove heat from said electronic device, leading to the cooling of the device. Since the movement of said pumping element is heat induced, an efficient fluid pumping can be achieved.

According to a preferred embodiment of the method according to the invention, the heat for moving the pumping element at least comprises heat which is produced by said electronic device.

In that case, the electronic device can at least partially be involved in the pumping of said fluid. Particularly, during use, the device produces heat, which heat is used in the moving of the pumping element for the pumping of said fluid to and/or from the device. Thus, the heat produced by the electronic device is not wasted. The heat transport from the device to the pumping element can, for instance, simply be carried out by said fluid. Besides, one or more separate heaters may be used to provide at least part of the heat for moving said pumping element. Also, a heat pipe may be used for the transport of said heat.

It is also an object of the invention to provide an alternative system, particularly a better system, for cooling at least one electronic device. The invention aims at providing an efficient system for cooling at least one electronic device.

According to the present invention, this object is achieved by the features of claim 12.

The system according to the invention comprises at least one movable pumping element for transporting a fluid, wherein said pumping element is movable by heat. Consequently, the system can operate relatively efficiently, using for example part of the heat which is produced by the device to be cooled. Besides, the movement of the pumping element may be achieved using no or substantially no electromagnetic radiation, which prevents disturbance of the operation of said electronic device due to such radiation.

The pumping element may, for example, be arranged to carry out a pumping movement under the influence of a heat induced pressure rise. Besides, the pumping element may, for instance, be arranged to carry out a pumping movement when the temperature of the pumping element changes. Such temperature change can be brought about by said heat. To that aim, the pumping element may contain and/or be coupled to heat sensitive material, material having a high thermal expansion coefficient, bi-metal and/or the like.

According to a further aspect of the invention, there is provided an electronic device, which is provided with and/or coupled to a system according to any of claims 12-31, wherein the electronic device particularly is part of a computing means, a computer, a server and/or the like.

Such electronic device can be cooled efficiently by said system, wherein the system preferably does not disturb the functioning of the device.

The invention further relates to an electronic product or apparatus, such as a magnetic tape or disc drive, an optical tape or disc drive, a TV-set, a monitor, a computer, a server or the like, the apparatus being provided with the system according to the invention.

Further advantageous embodiments of the invention are described in the dependent claims. Various combinations of characteristic features defined in the claims are options.

The invention will now be described in more detail on the basis of exemplary embodiments shown in the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a schematic drawing of a first embodiment of the invention;

fig. 2 is a schematic drawing of a second embodiment of the invention, wherein the pumping diaphragm is in a first position; and

fig. 3 is a drawing similar to fig 2, wherein the diaphragm is in a second position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 shows a system for cooling an electronic device 1. The electronic device 1 can be, for example, a semiconductor device, a device comprising one or more amplification parts, a microelectronic device, an Integrated Circuit, a chip, a high current component, a resistor, and/or any other electronic or electrical device which may heat up during operation. The system is a part of an electronic product <u>50</u>.

The electronic device 1 is mounted onto a heat receiving chamber 2. The heat receiving chamber 2 is filled with a suitable heat transporting fluid, comprising for example one or more liquids and/or gasses. According to an advantageous embodiment, the fluid is or comprises air, since air is cheap and safe to use. Alternatively, said fluid may comprise for instance one or more refrigerants, for instance CFC's, HCFC's or such like refrigerating substances. Preferably, the electronic device 1 is mounted such, that the heat transfer coefficient between the device 1 and the fluid in the receiving chamber 2 is relatively high. A heat sink, heat exchanger and/or material having a high heat conductivity can for example be provided between the electronic device 1 and the content of the heat receiving chamber 2. Besides, the electronic device can at least partially be located within the heat receiving chamber 2.

During use, the electronic device 1 produces heat, which is at least partially collected by the fluid in the heat receiving chamber 2. The fluid, as well as heat contained therein, is removed from the heat receiving chamber 2 via a discharge line 21 towards a pumping chamber 3, while the heat receiving chamber 2 is replenished with fluid via a fluid supply line 23.

In the present embodiment, the fluid is pumped to and from the heat receiving chamber 2 by a movable diaphragm 4. To this aim, the diaphragm 4 forms a movable part of the wall of a fluid compression chamber 13, so that a first side of said diaphragm 4 abuts said compression chamber 13. The compression chamber 13 is provided with a fluid exhaust 14 comprising a first valve 15. The fluid exhaust 14 is connected to said heat collection chamber 2 via the supply line 23. Said first valve 15 is a one-way valve which allows fluid to flow from the compression chamber 13 via the exhaust 14 into the supply line 23. The compression chamber 13 further comprises a fluid intake 16 which is provided with a second valve 17. Said second valve 17 is also a one-way valve which allows fluid to flow into the compression chamber 13 from a return line 22.

The compression chamber 13 is provided with cooling means 5 which are arranged to cool the content of the compression chamber 13. In the present embodiment, the cooling means of the compression chamber 13 comprise a heat exchanger which is provided with cooling ribs 5 extending in ambient air. Therefore, heat can be transferred from the content of the compression chamber 13 into the environment thereof, resulting in the cooling of the fluid. Preferably, the inner walls of the compression chamber 13 comprise a heat absorbing material and/or coating to improve the cooling of the content of the compression chamber 13.

Fluid, flowing from the compression chamber 13 via the supply line 23 towards the heat receiving chamber 2, is preferably additionally cooled, for example, by providing suitable expansion means. To that aim, the exhaust valve 15 may be, for instance, an expansion valve which is arranged to control the amount of fluid flowing there through, such that a fluid which is compressed in the compression chamber 13 is expanded and cooled in a controlled manner by the exhaust valve 15. Such expansion valve may also be located downstream, in the supply line 23. The principles of such a cooling mechanism, using an expanding fluid, are known from the art.

During use, said fluid is supplied to the compression chamber 13 via said intake 16. In the compression chamber, the fluid is cooled using heat transfer via the cooling ribs 5. Besides, during use, the diaphragm 4 expands from a first to a second position, thereby

compressing the fluid in the adjoining compression chamber 13. In fig. 1, the first position of the diaphragm is represented by a solid line 4, whereas a dashed line 4' represents the second diaphragm position. The compressed fluid can be further cooled by the cooling ribs 5. The expansion of said pumping diaphragm 4 also leads to the pumping of said fluid. The compressed fluid flows from the compression chamber 13 via the exhaust 14 into the supply line 23. Preferably, the compressed fluid is expanded in and/or into the supply line 23, for instance by the first valve 15, leading to a further cooling thereof. The resulting cooled fluid flows from the supply line 23 into heat receiving chamber 2, so that the fluid can provide a cooling of the electronic device 1.

During the compression of the fluid in the compression chamber 13, the second valve 17 is preferably closed, so that no compressed fluid can flow backwards into the return line 22. The second valve 17 can be arranged to close due to the rising pressure in the compression chamber 13. Besides, valve control means can be provided for controlling the second valve 17. To this aim, the second valve 17 may be -for example- an electrically or electronically controllable valve.

Said valve control means can be, for instance, suitable electronics, a microcontroller, a computer, mechanical means or the like. Besides, such valve control means may comprise one or more sensors to detect movement of the diaphragm and/or a pressure rise in the compression chamber 13. Also, said valve control means may be arranged to cooperate with the pumping element 4 for a desired valve control. For instance, said valve control means can be coupled mechanically, electrically, electronically and the like to the pumping element 4. Such valve control means are not shown in the figures.

Furthermore, the first valve 15 is preferably opened substantially during and/or after the fluid is compressed in the compression chamber 13, for allowing fluid to flow via the exhaust 14 into the supply line 23. The workings of the first valve 15 are preferably similar to the above described workings of the second valve 17. For instance, the first valve 15 may open due to the rise in pressure in the compression chamber and/or the first valve 15 may be controlled by suitable valve control means.

After the expansion of the diaphragm 4, the diaphragm 4 contracts back to the first diaphragm position. Preferable at substantially the same time, the first valve 15 closes so that no fluid flows back from the supply line 23 into the compression chamber 13. Besides, preferably at the same time, the second valve 17 opens so that a new amount of fluid can enter the compression chamber 13 via the fluid intake 16. Also in this case, the movement of

the fist and/or second valve may be pressure induced and/or such movement may be brought about by valve control means

The embodiment shown in figure 1 comprises a pumping chamber 3 for pumping the fluid from said device 1. In particular, the pumping chamber 3 is connected to said heat collection chamber 2 via the fluid discharge line 21. A third one-way valve 7 is provided in an exhaust 6 of the discharge line 21. This one-way valve 7 is arranged to allow fluid to flow from the collection chamber 2 into the pumping chamber 3.

Furthermore, said pumping chamber 3 can be brought in fluid connection with said compression chamber 3 by said fluid return line 22. To this aim, an inlet 10 of the return line 22 comprises a fourth one-way valve which is arranged to let fluid flow from the pumping chamber 3 towards the compression chamber 13.

According to the present invention, the movement of said diaphragm 4 is heat induced. In the present embodiment, the heat for moving the diaphragm 4 at least comprises heat which is produced by said electronic device 1. This is simply achieved, by feeding fluid from the heat collection chamber 2 to the diaphragm 4. The system also comprises a separate heater 8 for providing part of the heat to move the diaphragm 4. Said heater 8 is arranged to heat the content of said pumping chamber 3. The heater 8 is controlled by a heater control and/or power supply 9. The heater 8 may comprise for example electrical heating means, for example one or more heating wires and/or resistances.

As is clearly shown, the diaphragm 4 separates said compression chamber 13 and said pumping chamber 3 from one another. The diaphragm 4 may, for instance, be or be part of the wall that separates the compression chamber 13 and the pumping chamber 3. A second side of said pumping diaphragm 4 abuts the pumping chamber 3. Preferably, the diaphragm 4 comprises a heat insulating material, so that substantially no or little heat can flow via the diaphragm 4 from the pumping chamber 3 to the compression chamber 13.

During use, the temperature as well as the pressure of the fluid in the collection chamber 2 rises. This is the result of the build up of heat, produced by the electronic device 1, in the collection chamber 2. Then, the third valve 3 is opened, for instance due to said pressure rise in the collection chamber 2, and/or by said valve control means. At about the same time, the fourth valve 11 is closed and/or is held in a closed position. The heated fluid then flows from the collection chamber 2 into the pumping chamber 3, resulting in a pressure rise in the pumping chamber 3.

Preferably, the pressure in the pumping chamber 3 is further raised by activation of the separate heater 8, whilst the third valve 7 is closed. According to a preferred

embodiment, the heater 8 generates a heat pulse to provide an instantaneous, short pressure pulse in the pumping chamber 3. During the operation of the heater 8, both the third valve 15 and fourth valve 17 are preferably closed. Because of the overall pressure rise in the pumping chamber 3, the diaphragm 4 is expanded from said first position to said second position, resulting in said compression of the content of the compression chamber 13, as has been described above.

After the heat induced movement of the diaphragm 4 to the second diaphragm position, the pressure in the compression chamber 13 drops. This is achieved, amongst others, by allowing fluid to flow from the compression chamber 13 into the heat collection chamber 2, leading to said cooling of the electronic device 1, as has been described above.

Next, at least the second valve 17 and fourth valve 11 are opened and/or open by themselves, so that fluid can flow from the pumping chamber 3 into the compression chamber 13 via the return line 22. As a result, the pressure in the pumping chamber 3 drops and the diaphragm 4 returns to its first position. Preferably, at about the same time, said first valve 15 is closed or closes, preventing an undesired backflow of fluid from the supply line 23 into the compression chamber 13. Then, the pumping cycle can be started all over again.

The system may comprise, for instance, spring means for returning the diaphragm 4 from the second position to the first position. Such spring means may be, for example, separate spring means and/or the diaphragm may contain such spring means, particularly by using a resilient diaphragm 4. On the other hand, the movement of the diaphragm 4 between the first and second position may be purely heat induced, particularly due to heat related pressure changes.

Because of the heat induced movement of the diaphragm 4, the fluid is circulated between said at least one device 1 and said fluid cooling means 5, 15. Herein, the fluid flows from the heat collection chamber 2 and the pumping chamber 3 into the compression chamber 13, and back to the heat collection chamber 2. Preferably, said diaphragm movement is a pulsating or vibrating movement, which can be achieved for instance by applying heat pulses in the pumping chamber 3. Such pulsating movement can also be achieved by providing appropriate valve control. Particularly, the valves 15, 17, 7, 11 are preferably controlled such with respect to each other, that the fluid substantially only flows in the described direction between said chambers 2, 3, 13.

In the second embodiment, which is schematically shown in figures 2 and 3, an electronic device 1 is attached to a heat collector 102. The heat collector is formed as a heat pipe 102. The heat pipe 102 is arranged to transfer heat from the electronic device 1 to

the pumping diaphragm 4, particularly by heat conduction, for heating up the pumping diaphragm 4.

In the second embodiment, the pumping diaphragm 4 is arranged to carry out a pumping movement when the temperature of the diaphragm 4 changes. The pumping diaphragm 4 may, for example, contain and/or be coupled to one or more heat sensitive materials, materials having high thermal expansion coefficients, bi-metal and/or the like.

Just as in the first embodiment, a first side of the pumping diaphragm 4 of the second embodiment abuts a compression chamber 13. However, the second side of the pumping diaphragm 4 of the second embodiment extends opposite part of said heat pipe 10. In particular, the second side of the diaphragm 4 is provided with a heat conducting plate 103 which touches the heat pipe 102, for the case that the diaphragm 4 is in the first position, see fig. 2. The diaphragm 4 is arranged to expand to the second position, shown in fig. 3, due to a temperature rise of the diaphragm. In this second diaphragm position, the heat conducting plate 103 is moved away from the heat pipe 102.

The compression chamber 13 of the second embodiment is arranged substantially similar to the compression chamber 13 of the first embodiment. In the second embodiment, a supply line 23', which is connected to the compression chamber 13, extends towards the electronic device 1 to cool the device 1 with a cooling fluid. The supply line 23' comprises a one-way valve 15, which is preferably an expansion valve for further cooling said cooling fluid. The compression chamber 13 comprises an inlet 16' having a one-way valve 17 for replenishing the compression chamber 13 with fluid, for instance ambient air.

During use of the second embodiment, heat is generated by the electronic device 1. Part of the heat is absorbed by the heat pipe 102, so that the temperature of the heat pipe 102 rises. In case the diaphragm 4 is in the first position, the heat pipe 102 also transfers part of the generated heat to the heat conducting plate 103 of the diaphragm 4, resulting in a temperature rise of the diaphragm 4. The diaphragm 4 then expands or moves to its second position, shown in fig. 3. Due to the expansion of the diaphragm 4, fluid is compressed in the compression chamber 13. The compressed fluid, which has been cooled by the cooling ribs 5 of the compression chamber 13, is then preferably expanded through an expansion valve 15, leading to a further cooling of the fluid. The cooled fluid then flows via the supply line 23' to the electronic device 1 for cooling the device 1.

Operation of the first valve 15 and second valve 17 of the second embodiment may be similar to the operation of those valves in the first embodiment. These valves 15, 17 may be moved, for instance, by pressure changes in the compression chamber 13 and/or by

suitable valve control means. Such valve control means are preferably arranged to cooperate with the pumping diaphragm 4, so that valve control is induced by diaphragm movements, and therefore also by the device generated heat.

After the expansion of the diaphragm 4, contact is lost between the heat pipe 102 and the heat conducting plate 103 of the diaphragm 4. Consequently, the diaphragm 4 cools down, for instance by heat radiation, convection and/or conduction. Because of the temperature decrease of the diaphragm 4, the diaphragm 4 returns from the second position to the first position, such that the heat conducting plate 103 is again in contact with the heat pipe 102. Then, the above described pumping and cooling mechanism can start all over again.

Alternatively, a further heater, which is not depicted, may be provided in the second embodiment for heating up the pumping diaphragm 4. Such further heater may be desired for instance, for the case that the device 1 generated heat flow is not sufficient for moving the diaphragm to a desired second position.

The present invention provides for a heat induced pumping of a fluid to and/or from a device for cooling the device. Preferably, the pumping is automatic. Besides, the heat that is produced by the device may be advantageously used for driving the pumping means, particularly the pumping element 4 and preferably also the valve means, so that the pumping is energy efficient.

Although the illustrative embodiments of the present invention have been described in greater detail with reference to the accompanying drawing, it is to be understood that the invention is not limited to those embodiments. Various changes or modifications may be effected by one skilled in the art without departing from the scope or the spirit of the invention as defined in the claims.

Said movable element 4 can have different forms, shapes and sizes and may comprise various materials. The movable element 4 may comprise, for instance, a membrane, diaphragm and the like. The movable element 4 may comprise, for example, resilient and/or elastic materials, one or more metals, alloys, plastics, rubber and suchlike.

Furthermore, one or more pumping elements may be used for pumping said fluid, wherein movement of at least one and preferably more of the pumping elements is heat induced.

Besides, the system can have different components in various forms and sizes, depending amongst others on the amount of cooling capacity which is desired, the available space for installing the system and similar considerations.

Furthermore, at least part of the system may be arranged to be mounted onto or near an electronic device 1 for cooling the device 1.

CLAIMS:

1. Method for cooling at least one electronic device, wherein a moving pumping element (4) pumps a fluid to and/or from said electronic device, wherein the movement of said pumping element (4) is induced by heat.

2. Method according to claim 1, wherein said heat at least comprises heat which is produced by said electronic device.

3. Method according to claim 1 or 2. wherein said heat is produced by at least one heater (8).

4. Method according to any of the preceding claims, wherein the movement of said pumping element (4) is a pulsating and/or vibrating movement.

5. Method according to any of the preceding claims, wherein fluid is compressed by the movement of said pumping element (4), wherein the compressed fluid is cooled, wherein the cooled fluid is transported to said at least one device.

6. Method according to any of the preceding claims, wherein said pumping element circulates said fluid between said at least one device (1) and fluid cooling means (5; 15).

7. Method according to any of the preceding claims, wherein said fluid comprises air.

8. Method according to any of the preceding claims, wherein said pumping element comprises a diaphragm (4).

9. Method according to claims 5 and 8, wherein said fluid is supplied to a fluid compression chamber (13), wherein a first side of said diaphragm abuts said compression

chamber (13), wherein heat is supplied to a second side of said diaphragm (4) for moving the diaphragm into the compression chamber (13).

10. Method according to any of the preceding claims, wherein said pumping element (4) is expanded from a first position to a second position by said heat, wherein the expansion of said pumping element leads to the pumping of said fluid.

11. Method according to claim 10, wherein said heat is removed from the pumping element (4) after said expansion, such that the pumping element (4) contracts to said first position.

12. System for cooling at least one electronic device, comprising at least one movable pumping element (4) for transporting a fluid to and/or from said device, wherein said pumping element (4) is movable by heat.

13. System according to claim 12, wherein said pumping element comprises a diaphragm (4) which is movable between at least a first position and a second position, for example an expandable and contractable diaphragm (4).

14. System according to any of claims 12-13, comprising cooling means (5; 15) for cooling said fluid.

15. System according to claim 14, wherein said cooling means comprise expansion means for expanding compressed fluid, for instance an expansion valve (15).

16. System according to any of claims 14 and 15, wherein said cooling means comprise a heat exchanger, particularly a cooling rib (5), for transporting heat from the fluid to an environment.

17. System according to any of claims 12-16, comprising a compression chamber (13) for compressing fluid, wherein a first side of said pumping element (4) abuts said compression chamber (13).

18. System according to claim 17, comprising a fluid supply (2, 23) for supplying fluid from said compression chamber (13) to said electronic device (1).

19. System according to any of claims 12-18, comprising a heat collector (2; 102) for collecting heat from said device.

20. System according to claim 19, wherein said heat collector comprises a heat pipe (102) which is connected or connectable to said pumping element (4) for providing heat to the pumping element (4).

21. System according to claim 19, wherein said heat collector comprises a fluid which is at least contained in a heat collection chamber (2).

22. System according any of claims 12-21, comprising a pumping chamber (3) for pumping fluid from said device, wherein a second side of said pumping element (4) abuts said pumping chamber (3).

23. System according to claims 21 and 22, wherein said pumping chamber (3) is in fluid connectable to said heat collection chamber (2).

24. System according to at least claims 17 and 22, wherein said pumping chamber (3) is in fluid connectable to said compression chamber (13), for example by a fluid connection (22) which comprises a one-way valve (11, 17).

25. System according to any of the claims 12-24, comprising at least one heater (8) for providing at least a part of the heat for moving said pumping element (4).

26. System according to claims 22 and 25, wherein said heater (8) is at least arranged to heat the content of said pumping chamber (3).

27. System according to any of claims 12-26, comprising valve means (15, 16, 7, 8) which are arranged to control the transport of said fluid.

28. System according to claim 27, wherein at least a part of said valve means are arranged to cooperate with said pumping element (4) for controlling the transport of the fluid, wherein, for example, said cooperation is mechanical, electric, electronic or the like.

29. System according to any of claims 12-28, wherein at least a part of the system is arranged to be mounted onto or near an electronic device for cooling said device.

30. System according to any of claims 12-29, wherein the pumping element (4) is arranged to carry out a pumping movement under the influence of a heat induced pressure rise.

31. System according to any of claims 12-30, wherein the pumping element is arranged to carry out a pumping movement when the temperature of the pumping element changes.

32. Electronic device, provided with and/or coupled to a system according to any of claims 12-31, wherein the electronic device particularly is part of a computing means, a computer, a server and/or the like.

33. Apparatus provided with the system according to any one of the claims 12 to 31.

ABSTRACT:

Method for cooling at least one electronic device, wherein a moving pumping element (4) pumps a fluid to and/or from said device, wherein the movement of said pumping element (4) is induced by heat.

The invention further related to a system for cooling at least one electronic device, comprising at least one movable pumping element (4) for transporting a fluid to and/or from said device, wherein said pumping element (4) is movable by heat.

(Fig. 4)

PHNL040053

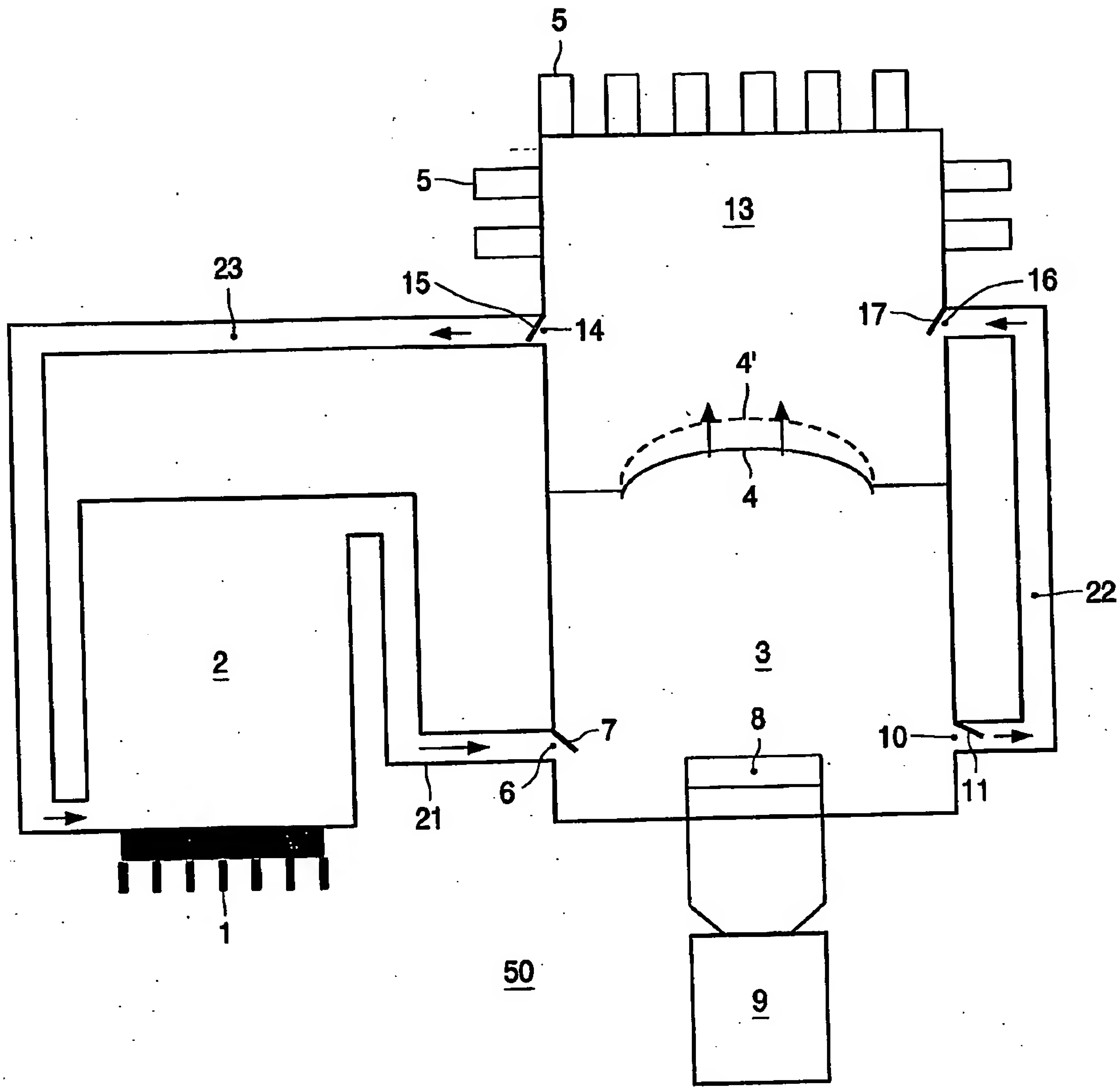

FIG. 1

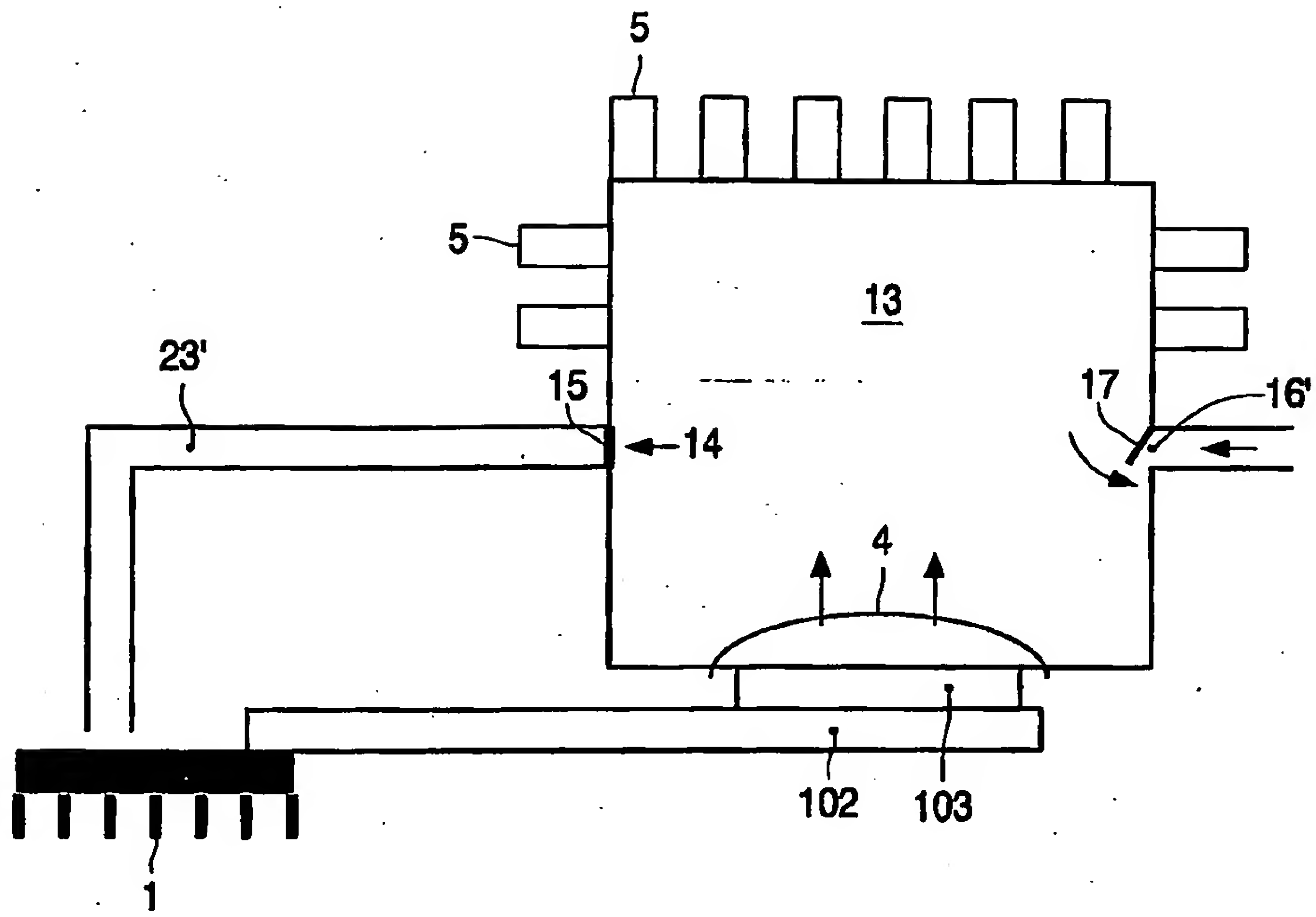

FIG. 2

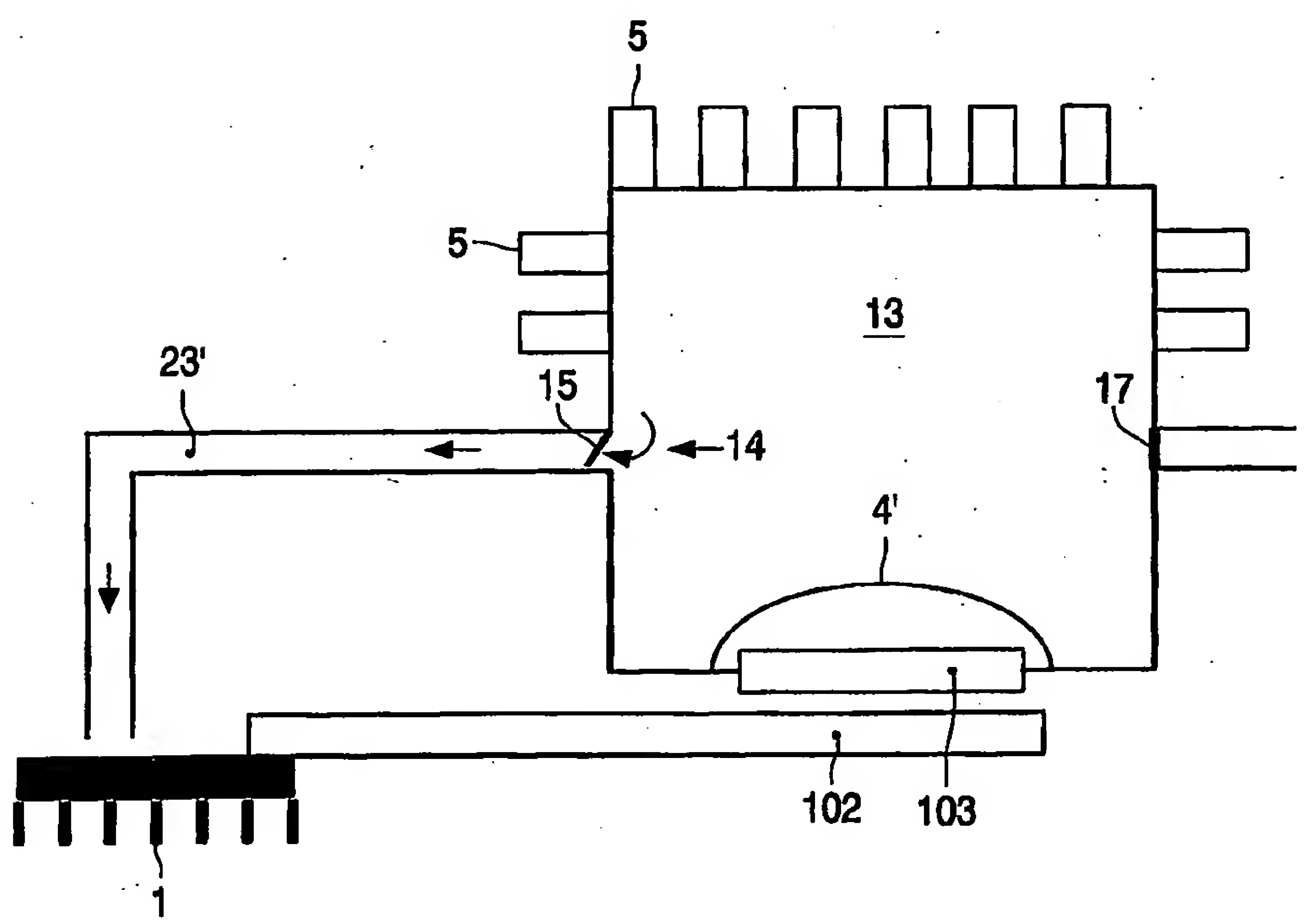

FIG. 3